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HIGH TIME RESOLUTION OBSERVATION OF THE TRANSIENT EVENT OF 5 MARCH 1979

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16. ABSTRACT

On March 5, 1979, a very intense and unusual gamma-ray burst was observed with the KONUS experiment aboard the Venera 11 and 12 spacecraft. This document reports the detection of this event with an instrument on the HEAO-2 spacecraft and the measurement of the time of onset of the event to a statistical uncertainty of 220 μs.

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INTRODUCTION

On March 5, 1979, a very intense and unusual gamma-ray burst was observed with the KONUS experiment aboard the Venera 11 and 12 spacecraft [1]. In fact, the burst has been detected [2] by eight detectors in the interplanetary gamma-ray burst monitor network which includes, in addition to the Veneras, the Pioneer Venus-Orbiter, the International Sun-Earth Explorer-3, Prognoz-7, and the four Vela satellites. This document reports the detection of this event with an instrument on the HEAO-2 spacecraft and the measurement of the time of onset of the event to a statistical uncertainty of 220 μs.

DISCUSSION

The characteristics which established the uniqueness of this particular event are [1, 2]: (1) the initial instantaneous increase in the flux, which was at least an order of magnitude larger than that of any other recorded bursts; (2) the extremely short initial rise-time, which occurred on a submillisecond time scale; (3) the short duration of the main event which, depending on the particular instrument, exhibited a rise to peak on the order of tens of milliseconds; (4) the smooth decay of the primary pulse; (5) a periodic pulsation ($\sim$8 s) superimposed on the decaying portion of the initial burst and persisting for many cycles; and (6) the energy spectrum, which appeared much softer than the typical spectrum of gamma-ray bursts.

The very sharp onset together with the distribution in space of the detectors is of special significance because the detector distribution permits an extremely accurate location by means of long baseline triangulation. Preliminary results [1, 3] have yielded an error box which includes the supernova remnant N49 in the Large Magellanic Cloud. The absence of other unusual objects in this field, together with the occasional association of supernova remnants with compact objects and high energy phenomena, appears to confirm this identification. However, recent optical observations[4] have led to other, although admittedly less unusual, candidates also in the current error box. Furthermore, imaging X-ray observations[5] have failed to find a point source anywhere within the field. Thus, it is extremely important to establish the source location as accurately as possible.

The Monitor Proportional Counter (MPC) on the EINSTEIN (HEAO-2) Observatory is a 1.5 mil beryllium window, argon gas-filled proportional counter with 667 cm^2 of active area. The instrument is coaligned with the X-ray telescope and is always operational except during passage through regions of high charged particle background. Nominally sensitive to X-rays in the bandwidth from 1.1 to 22 keV, the MPC is also sensitive to higher energy events present in sufficient quantities. Such events can be seen either in the low energy tail of the pulse-height distribution resulting from their interaction with the counter gas or through secondary events (Compton electrons or fluorescence photons) produced by the interaction with the mass surrounding the proportional counter. The strong intensity of the March 5 burst, its energy spectrum, and the position and orientation of the HEAO-2 spacecraft in Earth orbit allowed the detection of this singular event.

The counting rate as a function of time is shown in Figure 1. These data were recorded with the Time Interval Processor (TIP) electronics associated with the MPC. The TIP records the time between events to an accuracy of ±1.6 percent or 10 μs, whichever is greater. The variable accuracy results from a data compression scheme which leads to the loss of the least significant bits of the time interval and which depends on the actual length of the interval. In order that the uncertainty in event arrival times be kept at a minimum, a reference pulse is inserted in the data stream every 320 ms. The TIP circuitry also utilizes an on-board memory of limited capacity to store information when the data acquisition rate exceeds the telemetry readout rate. If the memory completely fills, no further data are recorded until the memory is entirely read out, a process which takes approximately 2.56 s. The high counting rate produced by the burst led to such a gap 56 ms after burst onset.

Many of the characteristics reported by the gamma-ray observers are confirmed in this observation: (1) the fast rise of the burst, the peak counting rate occurring approximately 18 ms after burst onset; (2) the featureless rise and fall of the burst (although limited here by counting statistics); and (3) the rapid onset of the burst, the time intervals between the first and second and second and third events being 0.488 ms and 0.134 ms with a background counting rate only of order 18 cs^{-1}.

The time of onset of the burst was established as follows: The background counting rate in the MPC was observed to be 18.54 cs^{-1} during the 37 s preceding and 414 s proceeding the 56 ms interval containing the burst. Of the 255 events recorded in this interval, we expect, on average, one not to be associated with the burst itself. Specifically, the first two events in the 56 ms occurred 48.80 ms and 49.29 ms after the last background event preceding the burst. Although a background event is more likely to have occurred near the beginning of the burst than at a later time, the probability of detecting a background event in the 0.49 ms interval between these two events and not in the preceding 48.80 ms is only 0.0090. Thus we can state with 99.1 percent confidence that the first count in the 56 ms interval

is associated with the transient event rather than background. The uncertainty in the time of occurrence of the burst is dominated by the Poisson uncertainty in the counting rate and not the accuracy to which we can measure the time of the first observed event (±71 μs). Based on the mean observed counting rate in the burst and assuming a sharp rise, we find the uncertainty in the burst onset to be ±220 μs (1σ). The time of occurrence was 57124.826908±0.000220 s UT on March 5, 1979, and the location of the HEAO-2 satellite at this time was latitude 22.15°, longitude -27.60° at an altitude of 525.0 km.

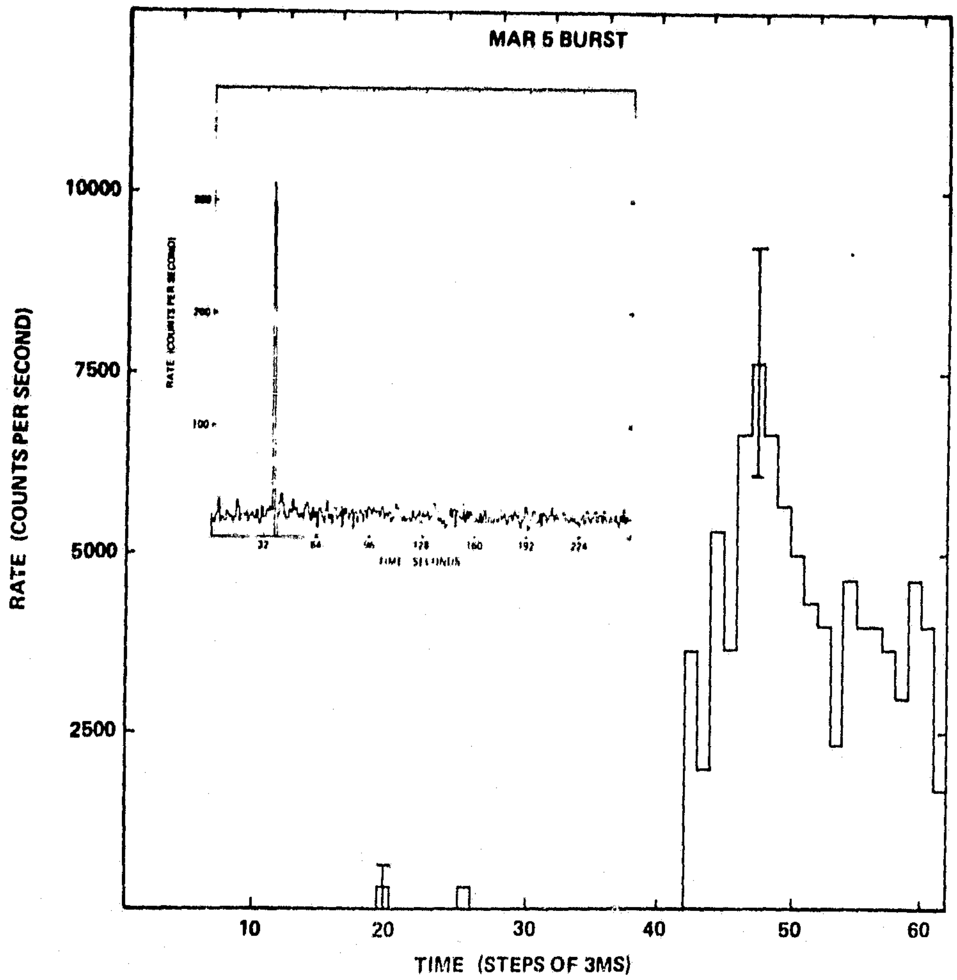

Figure 1. Counting rate as a function of time with the data binned in 3 ms intervals for 384 ms which include the burst. The error bars shown are ±1σ. The inset shows the entire observation which includes the burst with the data binned in 1 s intervals. The peak counting rate in the latter appears low due to the fact that the entire burst is contained in only 56 ms.

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APPROVAL

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The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

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